Taking you to the next level
Professional solutions for model based engineering and testing

Charles Glide, Martin zur Heiden

Copyright notice
This document or medium contains proprietary and copyrighted information and may not be copied, reproduced, translated, or reduced to any electronic medium without prior consent, in writing, from IPG Automotive GmbH.
Introduction – IPG Profile

One step ahead – advanced thinking, global solutions

As a former "spin-off" from the Technical University of Karlsruhe, IPG is the pioneer for Vehicle Dynamics and Hardware in the Loop Simulation

- 25 years experience within the vehicle dynamics field
- 18 years experience of HIL Test Systems
Field of Applications

Extended functions requires an advanced environment

Open model integration platform

Ensure your progress with our powerful support!

- Ramp-up Service
- Vehicle Engineering
- System integration and application
- Methods development
- Simulation services
- Customer specific software and hardware development

IPG Automotive GmbH
What makes IPG Automotive unique?

- Turn key solutions – ready to go!
- 25 years experience in the field of vehicle dynamics
- Multiple competences within one company
- Unique availability of sophisticated technology such as
  - Multi-Body Core MESA VERDE
  - Flex4Net system environment and Xpack4 real-time hardware for Office – Lab – Rig
  - IPGDriver the leading driver model
- Global Thinking and the ideas of their people!
Model Based Testing within an Integrated Development Process

- Safety Requirements
- Verification and Validation
- Product Release
- System design
- Model-based Optimization (SIL)
- Vehicle
- Vehicle Interface
- Real-time Simulation environment (Lab/Rig)
- Vehicle Simulation Software
- *dll
- MIL
- SIL
- ECUHIL
- NetworkHIL
- SimulatorHIL
- VehicleHIL

Integral process for functions, performance, fail safe mechanism and quality testing

- Model Based Optimization (SIL)
- CarMaker/Office
- CarMaker/HIL
- SimulatorHIL
- CompHIL
- Real-time HW
- Rig Control
- Network
- ECUHIL
- Vehicle
- Vehicle Interface
- Real-time HW
- Real-time HW
- Vehicle Interface
- Real-time HW
- Vehicle Interface
- Real-time HW
Open Perspective with IPG Simulation Solution

CarMaker Flex4Net technology guarantees the highest performance, flexibility, interactivity, productivity and precision

IPG Automotive GmbH

Professional Simulation Environment for virtual test driving

CarMaker MotorcycleMaker TruckMaker

All based on Multi-Body Code automatically generated with MESA VERDE

fully non-linear – symbolic – fast – extendable

IPG Automotive GmbH
“The virtual test department”

<table>
<thead>
<tr>
<th>Test Vehicles</th>
<th>Test Driver</th>
<th>Proving Ground</th>
<th>Traffic</th>
<th>Test Trailer</th>
<th>Test Operation</th>
<th>Test Docu</th>
<th>Online Data Acquisition</th>
<th>Test Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPGCar</td>
<td>IPGDriver</td>
<td>IPGRoad</td>
<td>IPGTraffic</td>
<td>IPGTrailer</td>
<td>ScenarioManager</td>
<td>TestSeries</td>
<td>IPGMobile</td>
<td>ScriptControl</td>
</tr>
</tbody>
</table>

**IPG Automotive GmbH**

---

**CarMaker Model Basis**

**IPGCar** – precise and extendable

- 17 DOF - Degrees of Freedom + 20 constraints
- **Mesa Verde** Multi-Body Code
  - fully non-linear – symbolical – fast – extendable

**Components**

- **Body**
  - BodyFlex with 2DOF (torsion, bending)
  - sprung mass, loads, engine, trim loads
- **Suspension** with linkage equation
  - kinematics & compliance selectable
  - 2D table (map), 1D table, linear
  - Damper, spring, buffer, stabilizer, external forces
- **Steering System** Front Axle
- **Rear Axle Steering**
- **Detailed Hydraulic Model** valid for ABS/ESP
  - Booster, master and brake cylinder, pump, valves, line volume, accumulator, attenuator
- **Powertrain** (front, rear, AWD)
  - Engine, clutch, gear box, differentials
- **3D Aerodynamics**
  - drag – lift – side
  - $3 F_{x,y,z}$, $3 M_{x,y,z}$

---

**IPG Automotive GmbH**
CarMaker Model Basis & Functions

- IPG Trailer
  - Full non-linear
  - up to 2 axles
  - free-definable geometry adjustable
  - unsprung, sprung masses, trim loads
  - IPG suspension model
  - sleeve axle, crank axle, semi-trailer arm axle
  - Aerodynamics model
  - Brake model
  - Tire model
  - Hitch ball model
  - Balltrapsze, friction, damper

- IPG Tire
  - MF 5.2 data load
  - TMY format
  - Additional functions
    - stop & go (HiL)
    - slope parking
    - vertical damping
  - 3DRoad usage
  - Physically based analytical functions for
    - combined Xf forces
    - Dynamic behavior
  - Tire load all or single
  - Automation fitting tool for IPG tire data

- IPG Road
  - 3D Road generator
  - 3D-track grid data load
  - Friction definition
    - μ split, μ-jump, μ-sequence, μ-line
  - Markers and Pylons
  - Traffic signs
    - speed, side wind
  - Obstacles
    - wave, cone, cylinder, beam
  - 3D-Track grid data load
  - High resolution: CRS

- IPG Traffic
  - Traffic generator
    - longitudinal - lateral
  - Different vehicle types
    - Trucks, Vans, SUV, passenger cars, HP cars
  - Maneuver definition
    - start position, time history, speed profile (x,y), acceleration
  - No limits on number of vehicles
  - Moving or standstill traffic
  - Paired vehicles
  - Traffic loop

CarMaker Online Tool & Functions

- IPG Movie realistic vision for your online evaluation and cognition
  - Online Animation for Office and HIL applications
  - Simultaneous force display
  - Comparison mode for primary and reference vehicle
  - Movie Control Panel for play back mode:
    - forward motion – regression – slow and fast motion
  - Load functions of results data for post-animation
  - Numerous view functions and camera settings
    - Very fast zoom and rotation by mouse
    - Offset settings (x,y,z)
    - User defined multi-default view positions
    - Fixed and moving camera
    - In vehicle and with vehicle motion
  - Extensive possibilities for individual adaption
    - Background, ambient and colors
    - Company Logo
  - Configurable Video Export to Cinepak
    - Indeo, MPEG, DivX, WMV

IPG Automotive GmbH
CarMaker Tool Environments

How much time do you have? Lights-out testing with ScriptControl

- Full Test Automation up to 20 x increase in productivity
- RealTimeExpression – test execution in real-time
- Easy implementation and application
- Dynamic and direct access to all commands, models, parameters, variables, data and mechanisms within CarMaker
- Exchange of models “on the fly”
- High functionality
  - Time, event and result controlled/triggered
  - Mathematical operations (expressions)
  - Commands (loops, case differentiation etc.)
  - Program Operations
  - Function generators
  - Calling of external programs
- Design of user specific GUIs
- Continuous use for MIL, SIL, HIL
- Reproducible, achievable and modular test flows
- Automatic generation of test protocols and reports

CarMaker Online Tool & Functions

CarMaker integration within MATLAB/SIMULINK

- Integration with the complete functionality of CarMaker
- CarMaker Models integrated as a Simulink block set
- Sub-segmented to all car sub-systems makes customization easy
- Simple user modification – extension – replacement of blocks
- Use of the respective tool specific model solvers and step size
- Same GUI, same models, same test runs, same parameters and the same mechanisms
- Direct access to all variables
- Parallel C-interface for all subsystems for C-Code model adaption and performance improvement
- Same performance optimized simulation code using multi-threading, multi-rating and multi-tasking
Use the potential with IPG Test Systems

**CarMaker/HIL** and **Xpack4** Technology
The Optimal Solution for your Challenges!

IPG Automotive GmbH

---

The optimal solution for your technologies

**Individual Test** Systems

**Standard HIL** Systems

Brakes – Driving Dynamics – Steering – Drivetrain
Driver Assistance – System Combinations

on basis of **Xpack4** real-time platform, **CarMaker/HIL** simulation environment

IPG Automotive GmbH
Xpack4 Realtime Hardware Structure

Host Computer

Realtime Computer

Multiplex insanely

Host ECU

Supported Realtime platforms by CarMaker/HIL

- **Xpack4** – IPG’s 4th generation
  - Intel-CPU, Compact PCI-bus, IPG Xeno Linux RealTime
    - CPU’s: F14c, F14p, F17 Core 2 Duo 2.16 GHz, 2048 MB RAM, 2x Gigabit Ethernet performance approx. 2x (5x MVME 550)
  - **NEW**
- IPG PowerPC-CPU, VMEbus, LynxOS
  - CPU’s: MVME 2400, MVME5100, MVME5500
- dSPACE DS1006 Opteron
- **NEW**
- dSPACE DS1005 PowerPC
Xpack4 Standard of-the-shelf Components

Take part of the quality and rapid progress of industry components!

Open standard, industry-of-the-shelf components:
- PCs as host computers with
  - Windows or Linux
- Scalable real-time computer
  - PowerPC or Intel SBCs
  - VMEbus or CompactPCI bus
  - LynxOS or IPGXeno Linux RT
  - M-Modules for I/O
- Open through full compatibility to
  - MATLAB and SIMULINK

Very attractive pricing:
Turn-key Realtime Computer, typical HIL IO-configuration: 8.500 €
FailSafeTester - Functionality

More than a simple breakout box!

- For actuators and sensors
- Able to simulate electrical faults like
  - Interruption (cable breakage)
  - Loose contact
  - Contact resistance (corrosion)
  - Short circuit (against ground and against other cables)
  - Shunt (leakage current)
- Fully software programmable, without the need for manual patching cables, which means
  - Test can be completely automated
  - Fault can be either course-controlled or time-controlled
  - Complete test configuration can be stored and re-loaded
  - This is really automated testing!

FailSafeTester - Functionality

Up to 160 channels in one box, yet extremely compact

- Expandable and modular system up to 160 channels in one box (20 slots, controller card, backplane)
- Multiple chassis configuration possible, thereby allowing for an unlimited number of channels
- Controlled via CAN or serial interface
- **Easy programming** via scripting language
  - Perfect integration with CarMaker/HIL
  - Easy-to-use graphical user interface
  - Channel naming and failure definition controlled by software
  - “Manual” (via mouse click) and automatic cable patching possible (via maneuver control dialog)
  - Control the fault modes from within your testrun and monitor the fault conditions
Robust Power - Turn Key Solutions from Concept to Delivery!

CarMaker at Opel: MIL – SIL – HIL

- Applications:
  - ABS, ESP, CDC/SADS, TCM, ECM, EHPS, CIM
- Tests:
  - Electrical and communication
  - Fail-safe and diagnostics
  - Function and performance
  - Pre calibration of ECUs
- Integrated models and available interfaces:
  - Tire model, brake hydraulics model
  - GM Test Automation
  - Automated flashing of ECUs
  - Interface to MATCAR, Chassis Studio
The Principle of HILSystem/ESP

**CarMaker Software Package**

- **IPG-ROAD**
  - Roadway information
  - Dynamic surface

- **IPG-CAR**
  - Hydraulic Brake System
    - Pressure
    - Force

- **IPG-TIME**
  - Time

- **IPG-Driver**
  - Steering-wheel angle
  - Throttle
  - Brake

**ESP Test Rig**

- **ESP - Hydraulic Brake System**
  - Pressure
  - Force

**FailSafe Tester**

**Sample Plug-In TestBox for ESP-ECU**

- Original cable tree with original connector
- Connection to Signal I/O and Power Supply
- Wheelspeed signal conditioning
- Magnetic valves sensing
- Sensor Box: Magnetic valves signal acquisition and conditioning
- Signal dispatching and arbitrary signal access